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THE QUEENSLAND JOURNAL OF AGRICULTURAL SCIENCE

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JUNE, 1955.

STUDIES ON CONDENSED WHALE SOLUBLES IN CHICK STARTER RATIONS.

By F. N. J. MILNE, B.Sc., Husbandry Officer (Poultry), Poultry Branch, Division of Animal Industry.

SUMMARY.

Condensed whale solubles from two sources were used to partly or wholly replace meatmeal in chick starter rations.

High mortality, many cases of dermatosis and depressed growth rate occurred when a batch of C.W.S. that had been stored for at least 18 months was used as a sole source of protein. Even at the lowest level of C.W.S. (8%) used in combination with meatmeal (3%), the number of cases of dermatosis was highly significant and growth rate was reduced.

When C.W.S. of a later date of manufacture was used, dermatosis and reduced growth rate occurred in the groups fed C.W.S. either alone or in conjunction with meatmeal. The addition of livermeal (a source of the vitamin B complex) at the rate of 4% in a chick mash containing 14% C.W.S. acted as a corrective.

It would seem that C.W.S. is deficient in one or more members of the vitamin B complex, particularly biotin.

There is evidence that rancidity of the fat content of C.W.S. may increase with storage and that such rancidity may inactivate biotin in feed mixtures.

I. INTRODUCTION.

Condensed whale solubles (hereafter referred to as C.W.S.), a by-product of the whaling industry, are now being produced in limited quantities in Western Australia, where poultry producers are using the product to augment supplies of meatmeal.

Cumber (1951) has reported favourably on the inclusion of 5% C.W.S. in a laying ration.

The value of C.W.S. in chick starter rations was investigated by Lassen, Bacon and Dunn (1951), who added it in varying quantities to "corn-soybean" rations supplemented with a full range of B-complex vitamins, including

vitamin B_{12} and the amino acid cystine. They reported that C.W.S. compares favourably with condensed fish solubles as a source of animal protein. In New South Wales, McDonald and McClymont (1953) found that C.W.S. can be used as a satisfactory source of protein, provided they are supplemented with 7% whey powder.

Preliminary work by Milne (Rumball 1952) on the "animal protein factor" potency of C.W.S. fed at low levels in all-vegetable protein rations suggested that the presence of 6% C.W.S. improved growth rates in comparison with those obtained with rations containing 2% and 4% C.W.S. respectively.

A more direct approach to the value of C.W.S. in chick starter rations was made by using rations wherein meatmeal was replaced wholly or partly by C.W.S.

The experiments reported here deal with the partial and complete replacement of meatmeal by C.W.S. in starter rations fed to chickens from one week to seven weeks of age.

II. EXPERIMENT 1.

(1) Procedure.

Commercial whale solubles that had been stored for 18 months were used. As the total crude protein content (53·2%) was of the same order as that of the meatmeal used throughout the experiment (55%), replacement was made on a pound for pound basis. All rations were supplemented with vitamin A and D_3 fish-oil emulsion, synthetic riboflavin and manganese sulphate.

Two hundred day-old Australorp cockerels obtained from a commercial hatchery were divided into four groups and housed in a four-deck, electrically-heated battery brooder.

To offset any vitamin B_{12} "carry-over" from the parent birds, an all-vegetable protein ration containing the following percentages of ingredients was fed for the first week from day-old: wheatmeal 43%, bran 15%, pollard 20%, peanut oil meal 20%, bonemeal (5% protein) 2%, salt premix (containing $MnSO_4$ 16g. and synthetic riboflavin 160 mg.) 1%, and vitamin A and D_3 fish-oil emulsion.

After one week on this diet, obvious culls were removed and the remaining chickens were wing-banded and individually weighed. They were then randomised on a class-weight basis to give four experimental groups each

of 47 chickens. Each group was fed one of the four experimental rations shown in Table 1 until the completion of the test. The food consumption of each group was recorded.

At four weeks of age, the birds were transferred from the battery brooders to weaning cages without heat.

At 5 weeks and 7 weeks of age, the chickens were individually weighed and the feathering of each bird assessed.

(2) Results.

The results are presented in Table 1. Highly significant weight differences (·1% level) were found at 5 weeks and 7 weeks of age, these differences becoming greater as the quantity of C.W.S. in the ration increased. Of even greater significance was the incidence of dermatosis and the high mortality at the 16% C.W.S. level (Group R4A).

Table 1.

EXPERIMENTAL RATIONS AND RESULTS OF FEEDING—Experiment 1.

	Group R1A.	Group R2A.	Group R3A.	Group R4A.
Ration Ingredient—	lb.	lb.	lb.	lb.
Wheatmeal	40	40	40	40
Bran	15	15	15	15
Pollard	26	26	26	26
Meatmeal	16	8	4	Nil
C.W.S. (53%)	Nil	8	12	16
Bonemeal	2½	2½	2½	2½
Salt premix*	½	½	½	½
	fl. oz.	fl. oz.	fl. oz.	fl. oz.
Vitaminised A and D_3 emulsion	2	2	2	2
Results of Feeding—				
Average weight at 1 week (oz.)	1·9	1·9	1·9	1·9
Average weight at 7 weeks (oz.)	23·0	19·2	17·0	14·0
Average gain in weight (oz.)	21·1	17·3	15·1	12·1
Feed gain ratio	3·38	3·89	4·25	†3·94
Birds with dermatosis at 7 weeks (%)	Nil	42	48	75
Mortality (%)	10·6	10·6	16·1	53·2

* Every ½ lb. common salt contained 16 g. manganese sulphate and 160 mg. synthetic riboflavin.

† Too much significance should not be placed on this figure because of the heavy mortality during 6th and 7th weeks of the experiment.

(a) Dermatosis.

This condition was first noted at four weeks of age (three weeks on C.W.S. rations) in chickens in group R4A. The feet were becoming dry and scaly, and the scales on the dorsal aspect of the feet were losing their "bloom" and becoming roughened. A few severe cases were found where calluses had developed, or where the whole of the under surface of the foot was becoming cornified and then fissuring, the condition being accompanied by bleeding.

A week later the condition was more pronounced, with fissuring and bleeding in many birds. Some were so badly affected that they had great difficulty in walking on the wire floors of the cages. Fig. 1 shows the condition in a chicken from Group R4A.

Fig. 1.

Dermatosis of an Experimental Chicken.

At six and seven weeks of age, a dermatosis rating was given to each bird and the "chi-square" test applied. The results are presented in Table 2, which shows that, in one week, both the incidence and the severity of the lesions had increased.

Table 2.

INCIDENCE AND SEVERITY OF DERMATOSIS AT 6 WEEKS AND 7 WEEKS OF AGE—Experiment 1.

Dermatosis Rating.*	Group.							
	R1A. 16% Meatmeal.		R2A. 8% Meatmeal + 8% C.W.S.		R3A. 4% Meatmeal + 12% C.W.S.		R4A. 16% C.W.S.	
	No. at 6 Weeks.	No. at 7 Weeks.	No. at 6 Weeks.	No. at 7 Weeks.	No. at 6 Weeks.	No. at 7 Weeks.	No. at 6 Weeks.	No. at 7 Weeks.
0	42	28	19	10	10	1	5	0
1	0	12	12	6	8	8	2	4
2	0	2	3	8	13	11	10	2
Total 0, 1 and 2 ..	42	42	34	24	31	20	17	6
3	0	0	2	10	4	9	7	4
4	0	0	3	4	3	9	5	7
5	0	0	2	3	0	0	3	5
Total 3, 4 and 5 ..	0	0	7	17	7	18	15	16
Chicks—3, 4 and 5 rating at 6 weeks (%)	0	..	17	..	18	..	47	..
Chicks—3, 4 and 5 rating at 7 weeks (%)	..	0	..	41	..	47	..	73

* 0 = Normal
1 = Slightly roughened soles
2 = Slight dermatosis
3 = Dermatosis and slight fissuring.
4 = Dermatosis and fissuring with and without bleeding.
5 = Dermatosis and severe fissuring and bleeding.

(b) Mortality.

The death rate was 53·2% in Group R4A and 16% in Group R3A.

In Group R4A 16 of 25 chickens that died showed similar pathological changes. The lesions were ecchymotic haemorrhages of the myocardium, congestion and petechiae in the kidneys and haemorrhages and white areas in the liver, representing old haemorrhages.

Two out of five chickens from Group R2A and five out of nine chickens in Group R3A exhibited one or more of the lesions of the C.W.S. syndrome.

Deaths began in group R4A eight days after the commencement of feeding and continued until they were 45 days old. Bacteriological examinations of these chickens were negative.

(c) Feathering.

Birds were scored individually on development of flight feathers, tail feathers and feather tracts on breast and back. The "chi-square" test was applied to the data and showed highly significant differences in feathering between groups at seven weeks of age.

III. EXPERIMENT 2.

(1) Procedure.

C.W.S. which were estimated to have been stored for no longer than five months were obtained from another source. The crude protein content was 44·1%, so the rations were reformulated (Table 3) to give a similar protein level (18%) for all four rations. This was about 1% lower than the average for Experiment 1.

Table 3.

EXPERIMENTAL RATIONS AND RESULTS OF FEEDING—Experiment 2.

	Group R1B.	Group R3M.	Group R3L.	Group R4B.
Ration Ingredient—	lb.	lb.	lb.	lb.
Wheatmeal	41	38	38	36
Bran	15	15	15	15
Pollard	26	26	26	26
Meatmeal	15	4	Nil	Nil
C.W.S. (44%)	Nil	14	14	20
Livermeal	Nil	Nil	4	Nil
Bonemeal	2½	2½	2½	2½
Salt premix*	½	½	½	½
	fl. oz.	fl. oz.	fl. oz.	fl. oz.
Vitaminised A and D_3 emulsion	2	2	2	2
Results of Feeding—				
Average weight at 1 week (oz.)	1·7	1·7	1·7	1·7
Average weight at 7 weeks (oz.)	20·8	18·1	22·4	15·4
Average gain in weight (oz.)	19·1	16·4	20·7	13·7
Feed gain ratio	3·22	3·73	3·36	4·37
Birds with dermatosis at 7 weeks (%) ..	Nil	20	Nil	51
Mortality (%)	4	0	4	6

* Every ½ lb. common salt contained 16 g. manganese sulphate and 160 mg. synthetic riboflavin.

It was suspected that the rations in which C.W.S. were the major source of animal protein in Experiment 1 were deficient in one or more B-complex vitamins. A ration containing livermeal and C.W.S. was therefore included in place of the R2A ration (8% meatmeal and 8% C.W.S.) of Experiment 1.

The vitamin B_{12} depletion diet was fed to 240 day-old Australorp cockerels for one week. The unsuitable birds were culled out and the remainder were wing-banded, individually weighed and randomised among four experimental groups each of 50 chickens. The experimental rations were fed from 1 week to 7 weeks of age. Chicks were inspected for signs of dermatosis at 4, 5 and 7 weeks of age and individually scored. Individual feathering was assessed and scored at 7 weeks of age.

(2) Results.

The results of this experiment (Table 3) at 7 weeks of age paralleled those of Experiment 1.

Table 4.

INCIDENCE AND SEVERITY OF DERMATOSIS AT 4, 5 AND 7 WEEKS OF AGE—Experiment 2.

Dermatosis Rating.	Group.											
	R1B. 15% Meatmeal.			R3M. 4% Meatmeal + 14% C.W.S.			R3L. 4% Livermeal + 14% C.W.S.			R4B. 20% C.W.S.		
	No. at 4 Weeks.	No. at 5 Weeks.	No. at 7 Weeks.	No. at 4 Weeks.	No. at 5 Weeks.	No. at 7 Weeks.	No. at 4 Weeks.	No. at 5 Weeks.	No. at 7 Weeks.	No. at 4 Weeks.	No. at 5 Weeks.	No. at 7 Weeks.
0	44	43	44	29	15	21	44	42	47	30	11	8
1	2	2	2	7	10	9	4	6	1	6	11	7
2	3	3	2	10	17	10	0	0	0	5	7	8
Total 0, 1 and 2 ..	49	48	48	46	42	40	48	48	48	41	29	23
3	0	1	0	3	5	5	0	0	0	7	8	12
4	0	0	0	1	3	4	0	0	0	0	9	5
5	0	0	0	0	0	1	0	0	0	0	2	7
Total 3, 4 and 5 ..	0	1	0	4	8	10	0	0	0	7	19	24
Chicks—3, 4 and 5 rating at 4 weeks (%) ..	0	..	..	8	..	..	0	..	..	14·6	..	..
Chicks—3, 4 and 5 rating at 5 weeks (%) ..	..	2	..	..	16	..	..	0	..	..	39·6	..
Chicks—3, 4 and 5 rating at 7 weeks (%) ..	..	..	0	..	..	20	..	..	0	..	..	51·0

The "all-meatmeal" control ration produced average weights which were very significantly better than those on rations containing C.W.S. alone and C.W.S. plus meatmeal. Dermatosis was present in the latter groups. The ration that contained livermeal and C.W.S. was superior to all other rations, including the control ration, and dermatosis was not observed in the group on this ration.

(a) Dermatosis.

The incidence and severity of dermatosis were surveyed at 4, 5 and 7 weeks of age, and the respective ratings at these periods are set out in Table 4. The "chi-square" test applied to the data showed significantly more chickens with a high dermatosis rating in groups R3M and R4B than in other groups.

The incidence of dermatosis was not as high as in Experiment 1: 51% of the chicks showed 3, 4 or 5 rating compared with 73% in Experiment 1. The number of severe cases (rating 5) was 14·8% of the total number of survivors at 7 weeks of age in Experiment 2, compared with 22·7% of the survivors remaining in Experiment 1. No lesions of dermatosis were found in the group fed C.W.S. and livermeal (group R3L).

One chicken in the control group (group R1B) showed dermatosis at 5 weeks of age but could not be classed as "definite" at 7 weeks of age. Since the completion of this work, sporadic instances of dermatosis in chicks fed rations with meatmeal as the only source of animal protein have been seen during other nutrition experiments.

(b) Mortality.

The heavy mortality in Experiment 1 when C.W.S. were the sole source of animal protein did not occur in Experiment 2. Autopsies on two chickens (one from group R3L and the other from group R4B) showed lesions probably associated with the C.W.S. syndrome.

(c) Feathering.

The feather development was assessed, as in Experiment 1, at 7 weeks of age, but no significant difference was found between groups.

DISCUSSION.

In both experiments partial or complete replacement of meatmeal by C.W.S. resulted in lower average weights than in control groups fed rations with meatmeal as the only protein. The incidence and severity of dermatosis increased with the amounts of C.W.S. used in the rations.

C.W.S. mashes are obviously palatable, for chickens eat them avidly.

The vitamin B_{12} content of the rations might be considered as a possible cause of the poorer growth on the C.W.S. rations. Cumber (1951) gave the vitamin B_{12} value of C.W.S. as ·5 micrograms per gram, which compares more than favourably with ·31 micrograms per gram for livermeal and ·036 micrograms per gram for meatmeal (Peeler *et al.* 1951). On the basis of these values, the "all-meatmeal" rations contained less vitamin B_{12} than the "all C.W.S." rations. The "all-meatmeal" rations had a calculated vitamin B_{12} content slightly higher than a satisfactory level of 2·0 micrograms per lb. of feed for chicks (Davis and Briggs 1951).

Amino-acid deficiencies might also be partly responsible for the poorer growth on C.W.S. Lassen, Bacon and Dunne (1951) indicated that this product is low in cystine and tryptophane.

The lesions of dermatosis are suggestive of either biotin or pantothenic acid deficiency, for in either deficiency dermatosis and retarded growth are concomitant. Hegsted *et al.* (1940) showed that, although the external symptoms of biotin and pantothenic acid deficiencies are similar, involving both the feet and the mandibles, it is possible to distinguish between the deficiencies by the original site of the lesions. In pantothenic acid deficiency, lesions always appear first on the mandibles and later on the feet, and *vice versa* in the case of biotin deficiency. Dermatosis of the feet was more severe in biotin than in pantothenic acid deficiency.

In Experiments 1 and 2 lesions occurred on the feet only, and they were severe (Fig. 1).

Pavcek and Shull (1942) demonstrated that biotin was destroyed by rancidity. Since the C.W.S. used in Experiment 1 had been stored for 18 months, rancidity could have been responsible for the possible biotin deficiency. Peroxide values were determined for samples of meatmeal and C.W.S., for the control ration R1A and the "all-C.W.S." ration R4A. The peroxide numbers were: control ration, 1; 16% C.W.S. ration, 5; meatmeal, 1; C.W.S. 5. These values indicated slight rancidity in the C.W.S., and as only part of the fat in the C.W.S. ration came from C.W.S., there appeared to be an increase in rancidity in this ration after mixing and storing for four days. Rancidity was not investigated during Experiment 2, when C.W.S. of a later date of manufacture was used. This material was estimated to be approximately five months old. There are therefore two possible explanations for the occurrence of a "biotin-like" dermatosis in Experiment 2—(1) the development of rancidity during storage and/or (2) the deficiency of the C.W.S. used in the second trial in members of the vitamin B complex, particularly biotin.

Mortality was high (53·2%) in the group fed the all-C.W.S. ration (group R4A) in Experiment 1. McDonald and McClymont (1953) recorded a death rate of 16% on a low B-complex ration with 15% C.W.S. and no meatmeal. Biotin deficiency in ducklings was accompanied by mortality ranging between 20% and 30% (Olsen *et al.* 1948), and pathological changes in the heart and myocardium were noted. Sixteen out of the 25 chickens dead in Experiment 1 showed similar pathological changes, including ecchymotic haemorrhages of the myocardium. The C.W.S. syndrome was noted in only two chickens in Experiment 2.

Approximate biotin values for the control rations were calculated according to the data presented by Lampen, Bahler and Peterson (1942). These calculated values have not been presented in table form, as no biotin estimations were available for C.W.S.

In Experiment 2, the addition of livermeal (4%) to a ration containing C.W.S. (14%) appeared to supply the factor(s) not present in C.W.S., for the average weight of chicks fed this ration was significantly better than the control group fed 15% meatmeal, and very significantly better than the two groups fed rations containing C.W.S. or a combination of C.W.S. and meatmeal.

McDonald and McClymont (1953) also found that the use of B-complex rich feeds, whey powder and lucerne meal in chick starter mashes with 15% C.W.S. produced highly significant weight differences in comparison with mashes of the same C.W.S. content but without whey powder and lucerne meal.

Dermatosis was not observed at any stage of Experiment 2 in the group fed the ration containing C.W.S. and 4% livermeal.

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ABNORMALITIES OF THE VAGINAE OF MERINO EWES IN QUEENSLAND.

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SUMMARY.

Abnormalities were found in the vaginae of 6.5% of 2,903 Merino ewes examined by means of a speculum.

In four of six ewes examined post-mortem, the mid-third of the vagina was constricted. In the other two, an obstruction due to fibrous adhesions between the walls of the vaginae in the region where the hymen should be situated was found.

A small breeding trial with ewes having abnormal vaginae was conducted. The percentage of ewes that lambed was lower than in a flock of unaffected ewes.

Attention has already been drawn to low reproduction rates amongst flocks in Queensland (Moule 1952 a, b, c). However, few clinical observations appear to have been made upon the vaginae of Merinos in relation to fertility of ewe flocks.

In a Merino flock in north-western Queensland, 10% of ewes failed to breed in 1953, although mated with fertile rams for at least six weeks in both the autumn and the spring. It was decided, therefore, to examine the vaginae of ewes for evidence of any conditions likely to impair conception. The results of an initial examination of ewes in three flocks, reported here, indicate that the vaginae of 6·5% of the ewes examined were abnormal.

MATERIALS AND METHODS.

The vaginae of 2,803 ewes of mixed ages in two flocks were examined during April, 1954.

In the first flock 2,123 ewes were examined. They had been mated with rams in the usual circumstances prevailing in pastoral Queensland; 2½% of rams were liberated amongst the ewe flock for about six weeks. The sheep were in a paddock of about 4,000 acres.

The second flock comprised 680 ewes. All but the maiden ewes in this flock had been mated, under paddock conditions, at least once previously.

The ewes were examined as they came on heat. Oestrum was detected by the marks left on the rumps of the ewes following mounting by vasectomised rams, which had a mixture of grease and pigment painted on their briskets.

Each ewe was confined in dorsal recumbency and a speculum was inserted into her vagina. The speculum consisted of a clear glass tube made from a large test tube. It was about 15 cm. long and 2·5 cm. o.d., with an oval opening about 2·0 cm. wide and 2·5 cm. long blown in one end at approximately 30° to the longitudinal axis. The speculum was tapered gently at this end. The opening at the other end was the mouth of the original test tube.

The speculum could not be inserted into the vagina of some ewes. In these cases, the vagina was explored by digital palpation. This usually revealed a constriction in, or a partial occlusion of, the lumen of the vagina. The constriction was situated between 1 and 2 cm. anterior to the external urethral orifice and about 3 or 4 cm. anterior to the commissures of the vulva.

The third flock consisted of 100 ewes, each of which had been identified by a numbered ear tag since birth. These ewes were born in the spring of 1951 and were mated for the first time in 1953. The vaginae of the whole flock were examined by digital palpation in the winter of 1954. During the examination these ewes were restrained in the standing position.

INCIDENCE OF ABNORMALITIES.

In the first flock, 147 of the 2,123 ewes of mixed ages examined had abnormal vaginae. All of the affected ewes were born in 1951 and were mated for the first time in 1953. They were submitted to examination in 1954.

In the second flock, 37 of the 680 ewes examined had abnormal vaginae. Of the 37 abnormal ewes, 1 was about 16 months old, 14 were 21 months, 13 were 28 months and 9 were over 3 years of age.

Ten of the ewes in the third flock had abnormal vaginae. Subsequent reference to the breeding records showed that none of these 10 ewes had lambed as the result of the 1953 mating.

The smallness of the udders and the teats of the ewes with abnormal vaginae in the other two flocks suggested that they also had not lambed.

The three flocks had lambed reasonably well for Queensland conditions following previous matings. Between 50% and 80% of lambs had been marked from the ewes mated.

THE ABNORMALITIES ENCOUNTERED.

No abnormalities of the mucous membrane lining the vagina or of the cervix were observed.

It was not possible to pass the speculum more than 3 or 4 cm. into the vaginae of the abnormal ewes owing to the presence of a construction or an occlusion in the lumen. However, a glass rod $\frac{1}{4}$ inch in diameter could be passed through the speculum and inserted into the vagina. The ease with which this could be done varied considerably, but it was achieved without damaging any tissues. In each case the depth of the rod was inserted beyond the obstruction suggested that the vagina was of normal length. Digital exploration of the vagina when the ewes were in the standing position, and at intervals for three days after the initial examination, revealed that the condition was constant. Apparently it was not associated with oestrum or mating, and it did not appear to be of a temporary neuro-muscular nature.

Post-mortem examination was made of six of the affected ewes. On each occasion examination of the vagina immediately after the animal was killed revealed that the obstruction was still present. The entire reproductive organs were removed from the carcases. Macroscopic examination revealed no abnormality other than that in the vagina.

Two types of abnormality were observed.

In four cases the vagina had a slight "hour glass" appearance from the exterior. The mid third was constricted, although the walls of the vagina felt as though they were slightly thickened. The vagina was opened by making a longitudinal incision along the dorsal wall, commencing at the dorsal commissure. In three sheep, the walls of the vagina, at the constricted mid third, were thicker than those at the proximal or distal thirds. The mucosa appeared normal and there were no fibrous adhesions between the walls.

In the remaining two ewes on which post-mortem examinations were made, an obstruction could be palpated about 5 cm. from the commissures of the vulva. The lumen was patent but nothing larger than a glass rod $\frac{1}{4}$ inch in diameter could be passed through the full length of the vagina. An anular thickening, occupying about $\frac{1}{8}$ inch of the length of the vagina, could be felt through the walls at the site of the obstruction. A longitudinal incision was made along the dorsal wall of the vagina, commencing at the dorsal commissure. The obstruction was due to fibrous adhesions between the walls of the vagina in the region where the hymen should be situated. The lesions in one of these ewes are shown in Fig. 1.

Fig. 1.

Fibrous Adhesions between the Walls of the Vagina of an Affected Ewe.

EFFECT OF ABNORMAL VAGINAE UPON REPRODUCTION.

A breeding trial was conducted to determine the effect of abnormal vaginae upon reproduction.

Two rams were mated in a small paddock with 60 ewes whose vaginae were considered to be abnormal. A further 34 identifiable ewes with abnormal vaginae were mated under paddock conditions, together with about 1,000 other ewes. The ewes were examined about eight weeks after lambing was completed in the flock.

The results are summarised in Table 1.

Table 1.

RESULTS OF EXAMINATION OF EWES EIGHT WEEKS AFTER LAMBING.

—	In Small Paddock.	In Large Paddock.
Number of ewes with abnormal vaginae mated	60	34
Number of ewes with abnormal vaginae that lambed	34	14
Number of lambs	27	11
Percentage of lambs marked to ewes mated	45	32·3
Percentage of lambs marked to ewes mated in large flock of about 1,000 unaffected ewes	..	62

DISCUSSION.

The history of the sheep which precipitated these observations indicates that the abnormalities observed in the vaginae of some of the ewes may have an influence upon the reproduction rates of flocks.

The bearing which the condition has upon lamb-marking percentages under field conditions may depend upon the circumstances which prevail at the time of mating. Rams may persevere with one affected ewe in a small flock; in a large flock in which other ewes are coming in oestrum, they may leave a ewe with an abnormal vagina for others which are more accommodating.

Arguments might be advanced for the mating of older and more experienced rams with young ewes. Clinical observations made by two of us (Miller and Moule 1954) upon the reproductive organs of rams suggest that the joining of older rams with young ewes is not desirable. In addition, it might be preferable to mate younger rams possessed of more slender penes with young ewes.

Until the cause and the significance of these conditions have been determined, it is important to recognise their occurrence in sheep being used in experiments on fertility or on ovine genetics, where high reproduction rates are essential.

ACKNOWLEDGEMENTS.

These observations were made as part of a study into the fertility of sheep which is being financed under the Wool Research Trust Fund.

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STUDIES OF THE COCCOIDEA.

3. THE GENERA CHENTRASPIS, CLAVASPIS, LINDINGASPIS AND MORGANELLA IN QUEENSLAND.

By A. R. BRIMBLECOMBE, M.Sc., Senior Entomologist, Division of Plant Industry.

SUMMARY.

The genera Chentraspis, Clavaspis **and** Morganella **are represented in Queensland by the genotype only, while** Lindingaspis **is represented by three species. Each of these except two species of** Lindingaspis **is widely distributed.** Clavaspis herculeana **(Doane and Hadden),** M. longispina **(Morgan) and** L. rossi **(Maskell) are recorded from a variety of hosts and are of minor economic importance.**

INTRODUCTION.

The taxonomic study of the Coccoidea in Queensland has enabled the determination of the distribution and host range of many of the species. Identifications have been made in the genera *Chentraspis, Clavaspis, Lindingaspis* and *Morganella*, and these species are dealt with below. The records given represent localities and hosts of Queensland material in the collection of this Department. Hosts are repeated only for different localities; likewise localities are repeated only for different hosts. Unless acknowledgement is given, the records are from collections made by the author. Relevant synonymy and literature references are listed for both the genera and species. Type locality and host records are also listed and for each species notes are given on the more outstanding structural features, host relationships and economic importance.

Genus **CHENTRASPIS** Leonardi.

1897—*Chentraspis* Leonardi: Revista di Patalogia Vegetale: 6: p. 111.

Genotype.—Aspidiotus unilobis Maskell.

When this genus was established Leonardi included two species in it, viz. *Aspidiotus unilobis* Maskell and *A. extensus* Maskell. The latter, however, was removed by MacGillivray (1921, p. 392) and made the genotype of *Neoleonardia*. The genus *Chentraspis* remains monotypic and in distribution is confined to Australia.

Chentraspis unilobis (Maskell).

(Figs. 1-3.)

Synonymy.—

1894: *Aspidiotus unilobis* Maskell: Transactions of the New Zealand Institute: 27: p. 40.

1897: *Chentraspis unilobis* (Maskell): Leonardi: Revista di Patalogia Vegetale: 6: p. 111.

1897: *Aspidiotus* (*Chentraspis*) *unilobis* Maskell: Cockerell: United States Department of Agriculture: Technical Series No. 6: p. 27.

Type locality and host.—New South Wales: Blue Mountains on *Acacia* sp.

Other records.—Melaleuca leucadendra L. (sens. lat.), Brisbane, Jan. 1900 (H. Tryon), also Carbrook, Nov. 1949, Redland Bay, Jan. 1950, Woodstock, July 1950, and Ayr, Feb. 1953 (W. A. Smith). *Callistemon salignus* (Sm.) DC., Brookfield, Feb. 1947. *Callistemon viminalis* (Soland. ex Gaertn.) G. Don ex Loud., Brisbane, Apr. 1949.

Fig. 1.

Chentraspis unilobis. Outline of body, showing dorsal and ventral surfaces.

[*After Ferris.*

This species has been redescribed in detail by Morrison and Morrison (1922). The female scale is white, though usually dirty white, with yellow or orange coloured pellicles. The distinguishing microscopic feature of the adult female is the presence of the median lobes only, which are completely fused (Fig. 2).

Fig. 2.

Chentraspis unilobis. Enlargement of pygidium, showing dorsal and ventral surfaces. [*After Ferris.*

The host genera, *Melaleuca* and *Callistemon*, are closely related in the family Myrtaceae, and the regular collection of the insect on these plants casts doubt on the host record of the type specimen. The hosts are widely distributed in Queensland, and probably, when further collections of the insect are made, its distribution will be equally wide. Incidentally, specimens have been examined on *Melaleuca leucadendra* from Koolpinyah, Northern Territory.

Fig. 3.

Chentraspis unilobis. Scales on leaf of *Melaleuca leucadendra.*

The insect occurs on foliage and twigs but normally not in dense populations (Fig. 3), and the health of infested trees is not affected.

Genus **CLAVASPIS** MacGillivray.

1921—*Clavaspis* MacGillivray: The Coccidae: p. 391.

Genotype.—*Aspidiotus subsimilis anonae* Houser.

=*Aspidiotus herculeanus* Doane and Hadden.

The genus *Clavaspis* as established by MacGillivray contained two species, viz. *C. anonae* (Houser) and *C. herculeana* (Doane and Hadden), the former from Florida and Cuba and the latter from the Society Islands. These have been determined as synonyms and 10 other species from North America have been added (Ferris 1938a and 1942, pp. 31-2, and 1954). Only the genotype is known to occur in Queensland.

Clavaspis herculeana (Doane & Hadden).

(Figs. 4-6.)

Synonymy.—

1909: *Aspidiotus herculeanus* Doane and Hadden: The Canadian Entomologist: 41: p. 298.

1918: *Aspidiotus subsimilis* var. *anonae* Houser: Annals of the Entomological Society of America: 11: p. 163.

1921: *Clavaspis herculeana* (Doane and Hadden): MacGillivray: The Coccidae: p. 441.

1921: *Clavaspis anonae* (Houser): MacGillivray: The Coccidae: p. 441.

1941: *Clavaspis herculeana* (Hadden): Ferris: Microentomology: 6: p. 44.

Type locality.—Society Islands.

Other records.—*Erythrina* sp., Queensland, prior 1900 (H. Tryon). *Eriobotrya japonica* (Thunb.) Lindl., Pialba, Apr. 1912 (H. Tryon). *Cedrela toona* Roxb. var. *australis* (F. Muell.) C. DC., Imbil, Jan. 1938. *Cajanus cajan* (L.) Millsp., and *Ficus carica* L., Ipswich, May, 1944 (J. P. Kahler). *Ficus carica* L., Sunnybank, Aug. 1944. *Carica papaya* L., Rochedale, Apr. 1950.

This insect is listed overseas from Florida, Cuba, Peru, Texas, Panama and Mauritius (Ferris 1942).

Fig. 4.
Clavaspis herculeana. Outline of body.

[*After Ferris.*

The female scale is dark grey and the pellicles are greyish black. The distinguishing microscopic features of the adult female are the presence of median lobes only and a pair of large clubbed paraphyses (Fig. 5).

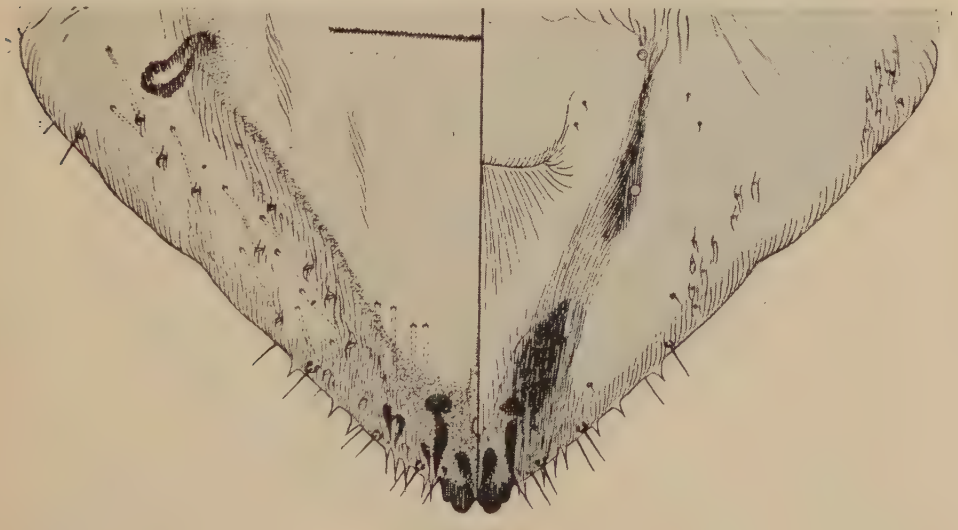

Fig. 5.
Clavaspis herculeana. Enlargement of pygidium.

[*After Ferris.*

Fig. 6.

Clavaspis herculeana. Scales on papaw fruit.

The variety and distribution of the host species suggest that the insect is more widely spread than is indicated by the present records.

The insects normally are in sparse populations but infestations on the cultivated fig and papaw fruit (Fig. 6) are evidence of pest potential.

Genus **LINDINGASPIS** MacGillivray.

1921—*Lindingaspis* MacGillivray: The Coccidae: p. 388.

Genotype.—Melanaspis samoana Lindinger.

The genus as established by MacGillivray contained only the genotype. A number of species have since been added, and McKenzie (1950), when reviewing the species referable to it, retained 16 names as valid. These show the genus to be widely distributed. Eight of the species were described from Pacific countries, six from Indian Ocean regions and two from Atlantic regions. All three species described from Australia occur in Queensland.

Lindingaspis neorossi McKenzie.

(Figs. 7-9.)

1950—*Lindingaspis neorossi* McKenzie: Microentomology: 15: p. 102.

Type locality.—New South Wales: Sydney.

Other record.—Xanthorrhoea sp., Mount Morgan, Aug. 1954 (T. Passlow).

The colour of the female scale is brownish black. Three small plate projections anterior to the third lobe distinguish the adult females (Fig. 8). The insects were crowded along the extremely long linear leaves of the host, and although adult females were normally circular, the narrowness of the leaves imposed an oval shape on many individuals.

Lindingaspis rossi (Maskell).

(Figs. 10-12.)

Synonymy.—

1890: *Aspidiotus rossi* Maskell: Transactions of the New Zealand Institute: 23: p. 3.

1897: *Aspidiotus* (*Chrysomphalus*) *rossi* Maskell: Cockerell: United States Department of Agriculture: Technical Series No. 6: p. 27.

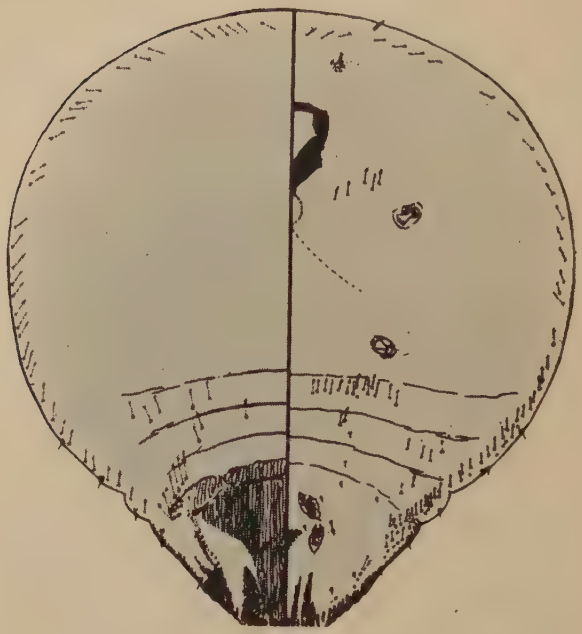

Fig. 7.

Lindingaspis neorossi. Outline of body.

[*After McKenzie.*

Fig. 8.

Lindingaspis neorossi. Enlargement of pygidium.

[*After McKenzie.*

Fig. 9.

Lindingaspis neorossi. Scales on *Xanthorrhoea* sp.

1898: *Chrysomphalus rossi* (Maskell): Leonardi: Revista di Patalogia Vegetale: 7: p. 202.

1938: *Lindingaspis rossi* (Maskell): Ferris: Atlas of the Scale Insects of North America: Second Series No. 246.

Type locality and host.—The type material was stated to be "very common about Adelaide, Melbourne and Sydney (Australia) on almost every kind of plant."

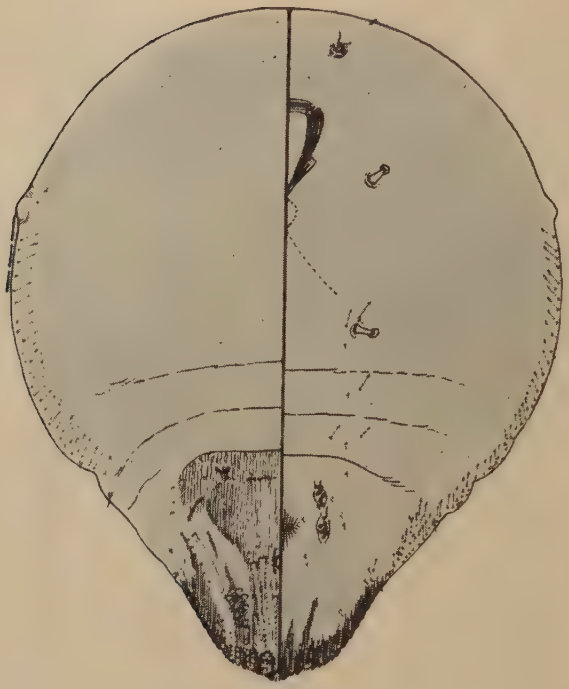

Fig. 10.
Lindingaspis rossi. Outline of body.

[*After McKenzie.*

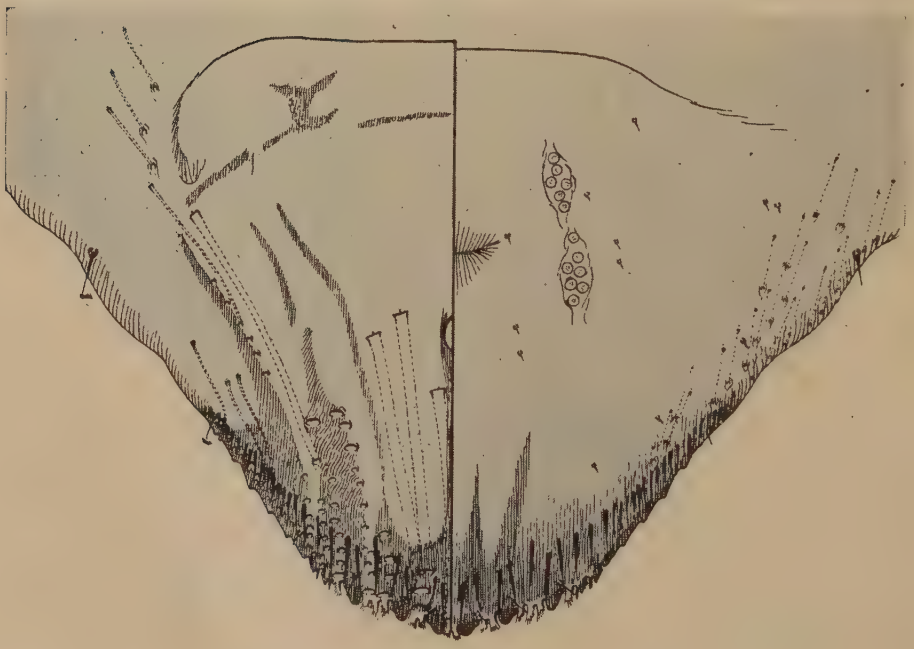

Fig. 11.
Lindingaspis rossi. Enlargement of pygidium.

[*After McKenzie.*

Other records.—A palm, Brisbane, Nov. 1899 (H. Tryon). *Tristania suaveolens* (Gaertn.) Sm., Rosewood, Nov. 1900 (H. Tryon). *Olea europaea* L., Blackall Ra., Sept. 1901 (H. Tryon), and Sunnybank, Mar. 1948. Cultivated plants, Enoggera, 1905 (H. Tryon). *Acacia cunninghamii* Hook., Enoggera, Nov. 1910, and Sunnybank Aug. 1914 (H. Tryon), also Moggill, May 1950, and Ormiston, Aug. 1950, and Ayr, Nov. 1953 (W. A. Smith). *Nerium oleander* L., Brisbane, Sept. 1915 (H. Tryon), also Pittsworth, Nov. 1950 (A. W. S. May), Gatton, Feb. 1953 (R. B. Wells), and Charleville, Sept. 1954. *Araucaria cunninghamii* D. Don, Brisbane, Sept. 1946, also Goodnight Scrub, Aug. 1939, and Imbil, Aug. 1942, also Ayr, Nov. 1953 (W. A. Smith). *Melaleuca leucadendra* L. (sens. lat.) Redland Bay, Aug., 1937, and Ormiston, Aug. 1950, also Ayr, Apr. 1951 (W. A. Smith). *Acacia penninervis* Sieb. ex DC., Mt. Gravatt, Oct. 1939 (W. A. Smith). *Eucalyptus resinifera* Sm., Samford, Dec. 1939. *Persea americana* Mill., Yarwun, Feb., 1940. *Eucalyptus siderophloia* Benth., North Aramara, May 1940. *Pinus taeda* L., Beerwah and Glasshouse Mt., Aug. 1940. *Dendrobium kingianum* Bidw., Brisbane, Apr. 1941. *Owenia venosa* F. Muell., Imbil, Aug. 1942. *Xanthorrhoea* sp., Brisbane, Mar. 1943, and Beerwah, May 1944. *Podocarpus elatus* R. Br. ex Mirbel, Brisbane, Mar. 1943. *Leptospermum citratum* Chall., Penf. and Cheel., Beerwah, May 1944. *Hedera helix* L., Brisbane, Apr. 1946, also Toowoomba, Nov. 1950 (A. W. S. May). *Mangifera indica* L., Brisbane, May 1946. *Callistemon salignus* (Sm.) DC., Brookfield, Feb. 1947. *Diploglottis australis* (G. Don) Radlk., Yarraman, July 1947. *Alstonia constricta* F. Muell., Yarraman, Aug. 1947. *Cupaniopsis anacardioides* (A. Rich.) Radlk., Yarraman, Aug. 1947, and Brisbane, May 1949. *Macadamia ternifolia* F. Muell., Nambour, Sept. 1947, Gayndah, Oct. 1947, Tamborine Mt., Apr. 1948, Brisbane, Sept. 1949, Dagun, Sept. 1950, and Sunnybank, Feb. 1952. *Banksia integrifolia* L.f., Tugun, Aug. 1947. *Eremocitrus glauca* (Lindl.) Swingle, Biloela, Oct. 1947. *Acacia fimbriata* A. Cunn. ex G. Don, Brisbane, Jan. 1947. *Buckinghamia celsissima* F. Muell., Brisbane, 1947. *Alectryon connatus* (F. Muell. ex Benth.) Radlk., Imbil, 1947. *Croton acronychioides*, F. Muell., Yarraman, July 1947. *Mallotus philippinensis* (Lamk.) Muell. Arg., Yarraman, Nov. 1947. *Tristania conferta* R.Br., Brisbane, Feb. 1948. *Eugenia coolminiana* C. Moore, Tamborine Mt., Mar. 1948. *Stenocarpus sinuatus* Endl., Tamborine, Mar. 1948. *Araucaria hunsteini* K. Schum., Tolga, Apr. 1948 (W. A. Smith). *Camellia japonica* L., Brisbane, Jan. 1948. *Cleistanthus cunninghamii* Muell. Arg., Brisbane, Feb. 1948. *Araucaria bidwillii* Hook., Imbil, Feb. 1937 and Brisbane, Apr. 1948. *Pleiococca wilcoxiana* F. Muell., Yarraman, Aug. 1948. *Callistemon viminalis* (Soland. ex Gaertn.) G. Don ex Loud., Brisbane, Apr., 1949, also Charlwood, Oct., 1953. *Araucaria excelsa* R.Br., Coolangatta, June 1949. *Loranthus alyxifolius* F. Muell. ex Benth. Yarraman, Sept. 1949. *Callicoma serratifolia* Andr., Springbrook, Jan. 1950. *Lomandra longifolia* Labill., Ipswich, Nov. 1952 (A. W. S. May). *Bologhia lucida* Endl., Yarraman, Mar., 1952, also Toowoomba, Sept. 1952 (A. W. S. May). *Celastrus bilocularis* F. Muell., Yarraman, Mar. 1952. *Dysoxylum* sp., Imbil, Apr. 1953. *Hovea longifolia* R.Br., Moggill, Sept. 1953. *Acacia*

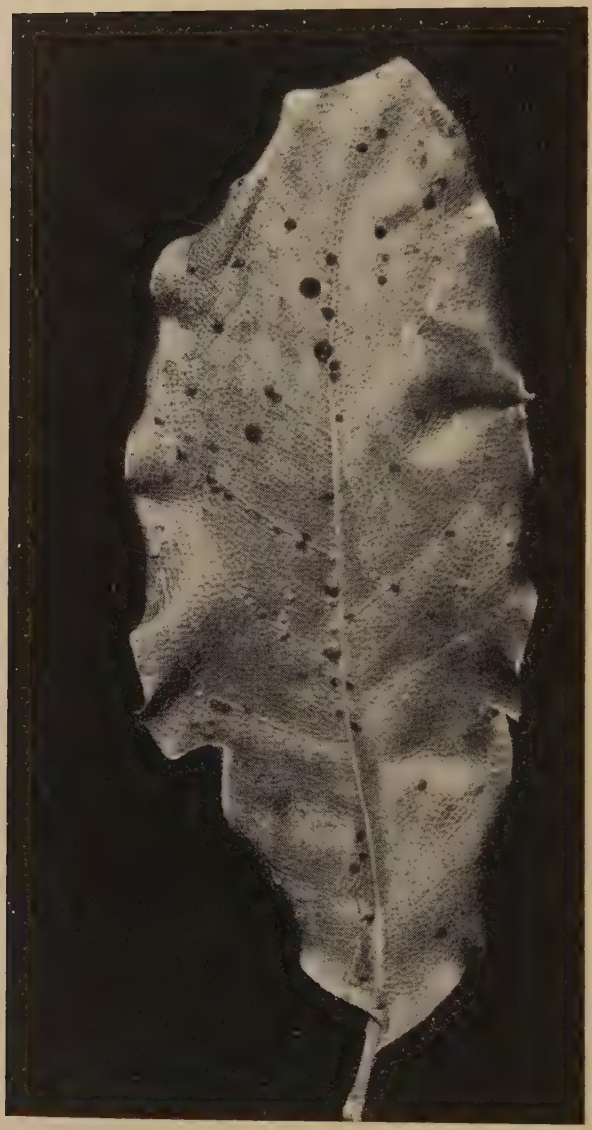

Fig. 12.

Lindingaspis rossi. Scales on *Macadamia ternifolia.*

aulacocarpa A. Cunn. ex Benth., Kenmore, Oct. 1953. *Capparis mitchellii* Lindl., Inglewood, Oct. 1954. *Pandanus pedunculatus* R.Br., Tugun, May, 1953. *Euonymus* sp., Stanthorpe, Aug. 1953 (A. W. S. May).

This species has been recorded from a variety of plants in other Australian States and is now known to occur in most countries bordering the Pacific and Indian Oceans. Several authorities have redescribed it, the latest being McKenzie (1950).

The female scale is flat and circular in shape and varies in colour from pale slaty-grey through dark-brown to black. These features are usually sufficient identification. However, the adult females are characterised by a fimbriate plate anterior to the third lobe (Fig. 11). The insects normally occur in sparse populations on the leaves of the hosts, more particularly on the upper surface (Fig. 12). While this species is one of the commonest in Queensland, parasites normally prevent it from becoming a troublesome pest.

Lindingaspis victoriae (Cockerell).

(Figs. 13-15.)

Synonymy.—

1899: *Chrysomphalus rossi* var. *victoriae* Cockerell: The Victorian Naturalist: 16: p. 8.

1950: *Lindingaspis victoriae* (Cockerell): McKenzie: Microentomology: 15: p. 107.

Type locality and host.—Victoria: Bacchus Marsh on *Eucalyptus globulus.*

Other records.—Acacia penninervis Sieb. ex DC., and *Eucalyptus* sp., Brisbane, Sept. 1915 (H. Tryon).

The present records apparently are the only ones in addition to that of the type material. The distance between the two localities suggests that the species is probably widely distributed, but perhaps in small populations. The female scale of this species is brownish-black. Adult females are distinguished by the reduced and branched plate anterior to the third lobe (Fig. 14).

The insects occur on both leaves and twigs, apparently in sparse populations.

Fig. 13.

Lindingaspis victoriae. Outline of body. [*After McKenzie.*

Fig. 14.

Lindingaspis victoriae. Enlargement of pygidium. [*After McKenzie.*

Fig. 15.

Lindingaspis victoriae. Scales on twigs of *Eucalyptus* sp.

Genus **MORGANELLA** Cockerell.

1897—*Aspidiotus* (*Morganella*) *Cockerell:* United States Department of Agriculture: Technical Series No. 6: p. 22.

1921—*Morganella* Cockerell: MacGillivray: The Coccidae: p. 389.
Genotype.—Aspidiotus (*Morganella*) *maskelli* Cockerell
=*Aspidiotus longispinus* Morgan.

When Cockerell established *Morganella* as a subgenus he listed two species, namely *maskelli* and *longispina.* In the same year Maskell described *ornatus* as a variety of *longispinus.* These three names have since been regarded as referring to the same insect (Ferris 1938b). Consequently the genus contains one species which occurs in Queensland.

Morganella longispina (Morgan).

(Figs. 16-18.)

1889: *Aspidiotus longispinus* Morgan: Entomological Monthly Magazine: 25: p. 352.

1897: *Aspidiotus longispinus* var. *ornatus* Maskell: Transactions of the New Zealand Institute: 30: p. 225.

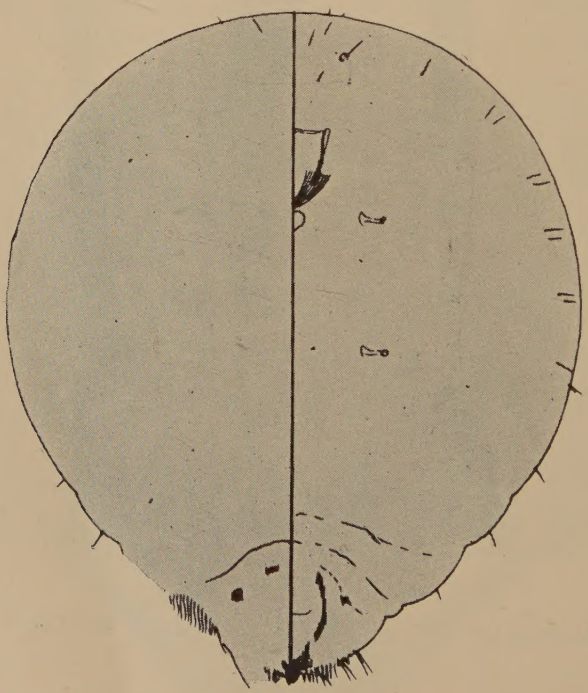

Fig. 16.

Morganella longispina. Outline of adult female.

[*After Ferris.*

Fig. 17.

Morganella longispina. Enlargement of pygidium.

[*After Ferris.*

1897: *Aspidiotus* (*Morganella*) *maskelli* Cockerell: United States Department of Agriculture: Technical Series No. 6: p. 22.

1897: *Aspidiotus* (*Morganella*) *longispinus* Morgan: Cockerell: United States Department of Agriculture: Technical Series No. 6: p. 24.

1897: *Hemiberlesia longispina* (Morgan): Leonardi: Revista di Patalogia Vegetale: 6: p. 120.

1921: *Morganella longispina* (Morgan): MacGillivray: The Coccidae: p. 426.

Type locality and host.—Demarara, Sandwich Is., on *Cupania sapida.*

Other records.—Ligustrum sinense Lour., Brisbane, Aug. 1914 (H. Tyron). *Ficus carica* L., Brisbane, Apr. 1933, and Sunnybank, Mar. 1934. *Cedrela toona* Roxb. var. *australis* (F. Muell.) C.DC., Imbil, May 1934. *Carica papaya* L., Cleveland, July 1940. *Macadamia ternifolia* F. Muell., Amamoor, Aug. 1941. *Nerium oleander* L., Brisbane, Jan. 1945. *Ficus macrophylla* Desf., Brisbane, June 1947. *Alectryon connatus* (F. Muell. ex Benth.) Radk., Yarraman, Aug. 1947.

This species is known to occur also in South Africa, Brazil, Algeria, Mauritius, Ceylon, New Zealand, Hawaii, and West Indies.

The scale is light to dark grey in colour, and fairly convex. Like *Chentraspis* and *Clavaspis* the adult female has only the median pair of lobes but the accompanying large plates enable ready recognition (Fig. 17).

Occurrence is normally on the twigs of the host plants. The insects sometimes are in dense populations (Fig. 18) and their presence on the cultivated fig has warranted control measures.

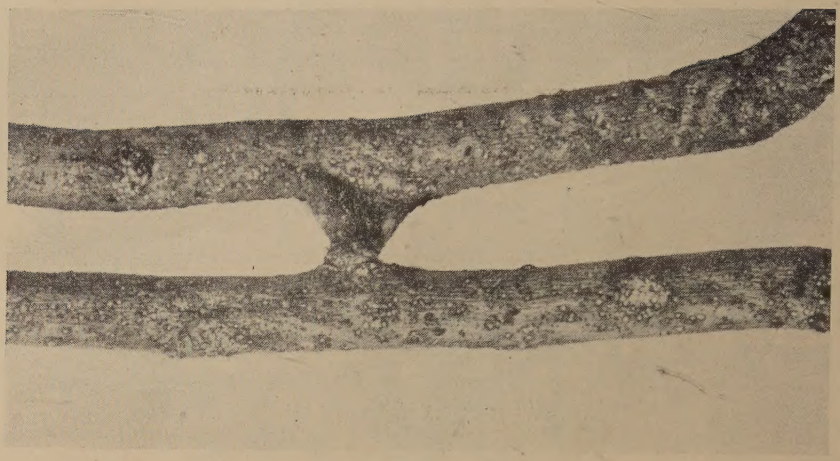

Fig. 18.

Morganella longispina. Scales on *Cedrela toona* var. *australis.*

ACKNOWLEDGEMENTS.

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A. H. Tucker, Government Printer, Brisbane.